

**REDUCING HIGH TEMPERATURE STRESSES ON COOL-SEASON GRASSES**

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**HIGH TEMPERATURE STRESSES DEFINED**

- 1. DIRECT.** Temperatures are sufficiently high enough to cause immediate death of the plant.
- 2. INDIRECT.** Turf growth is impaired but the high temperatures do not immediately kill the plant. Injury level may be from slight to total.

**OCCURRENCE OF HIGH TEMPERATURE STRESSES**

Direct	Indirect
unusually high temperatures	prolonged sub-lethal high temperatures
heat sensitive grass	heat sensitive grass
lack of transpirational cooling; no water or no roots	transpirational cooling reduced by poor air drainage, lack of water,
scald or low soil O <sub>2</sub> conditions	limited root system, high humidity
thin or close cut turf	close cut, thin turf
turf low in TNC or hardiness	turf low in TNC or hardiness

**INDIRECT HIGH TEMPERATURE SITUATIONS**

**Kentucky Bluegrass/Perennial Ryegrass or *Poa annua* Fairway**

- photosynthesis inhibition, reduced TNC for roots
- root maturation and dieback (low priority for TNC)
- shoot growth declines due to less TNC, some protein/membrane deactivation
- other stresses are accentuated shoot growth and stand density decrease---- wear, direct high temperature, drought, disease

Initial



**INDIRECT HIGH TEMPERATURE SITUATIONS**

**Summer Bentgrass Decline**

- SBD in hot, humid conditions (even with good greens mixes)
- SBD on shaded/poor air drainage sites\*
- SBD on greens with excessive fines and/or layers\*
- SBD on greens under salt stress\*

\* Multiple stress situations.

**SYMPTOMS OF HIGH TEMPERATURE STRESS**

Direct	Indirect <sup>z</sup>
rapid death of the plant	root maturation and dieback
	shoot growth declines
	loss of shoot density
	total death may or may not occur

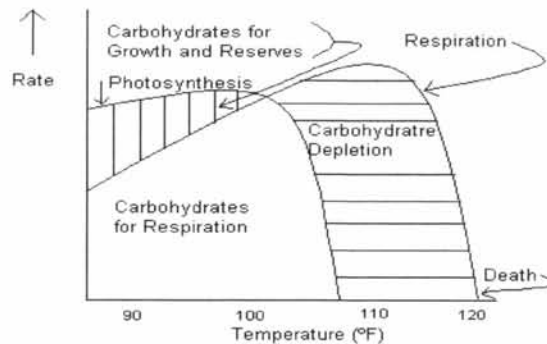
<sup>z</sup> Normal sequence over several days to weeks.

**DIRECT HIGH TEMPERATURE STRESS MECHANISMS**

1. **Protein Denaturation.** High temperatures cause certain proteins to coagulate and become denatured (no longer function). Protoplasm coagulates and causes cell wall breakdown.
2. **Membranes are Altered.** Temperatures cause membranes (ex. thylakoid membranes in chloroplasts) to become more fluid, more permeable, and not function. Photosynthesis (PS II) is especially sensitive to high temperatures.

**INDIRECT HIGH TEMPERATURE STRESS MECHANISMS**

1. **Inhibition of Photosynthesis**



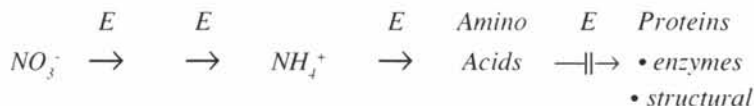
- Prolonged carbohydrate depletion leads to carbohydrate starvation.
- Differences occur at inter- and intraspecies levels.

**INDIRECT HIGH TEMPERATURE STRESS MECHANISMS**

Prolonged high temperatures not only Inhibits Photosynthesis but also

**2. Reduces Protein Function/Synthesis**

Heat sensitive enzymes start to denature and lose activity which leads to reduced total protein synthesis.



**3. Membranes Lose Function**

Heat sensitive membranes start to leak and lose activity.

**HIGH TEMPERATURE STRESS MECHANISMS: SUMMARY**

Direct	Indirect
1. Protein Denaturation (catastrophic)	*1. Inhibition of Photosynthesis
2. Membrane Deactivation (catastrophic)	2. Protein Deactivation Starts
	3. Membrane Deactivation Starts

IMPLICATIONS ???

**HIGH TEMPERATURE STRESS PROTECTION #1**

**1. Use Heat Tolerant Species/Cultivars**

- Heat tolerant grasses have:
- a more heat stable photosynthesis system
- greater thermal stability of heat-sensitive enzymes/proteins
- greater thermal stability of heat-sensitive membranes
- morphological features to reduce heat absorption\*
- possibly heat shock proteins for protection



- more TNC for shoot growth
- more TNC to maintain root growth and viability

\* pubescent leaves, waxy leaves, vertical leaves

Turfgrasses vary in **direct and indirect high temperature tolerance** at the species and intraspecific (cultivar, ecotype) levels.

- \* Species. Bentgrass vs *Poa annua*
- \* Intraspecific. Plush KB vs Nugget KB

### **HIGH TEMPERATURE STRESS PROTECTION#2**

#### **2. Maintain Transpirational Cooling**

- Adequate Soil Moisture (not too dry or wet)
- Adequate Root System. Problems are:
  - close mowing height
  - soil chemical, physical, or biological stresses that limit rooting
- Adequate Air Drainage
- Syringing to avoid moisture stress or water to evaporate from leaves.

### **PRIMARY SOIL FACTORS THAT INHIBIT ROOT GROWTH/VIABILITY**

#### **Soil Physical**

- high soil strength in bulk soil or layer
- low soil O<sub>2</sub> in bulk soil or layer
- high soil temperatures (c.s.)
- excessively dry soil or soil zone

#### **Soil Chemical**

- acid soil complex (deficiencies + toxicities)
- high salinity, especially Na<sup>+</sup>

#### **Soil Biological**

- soil pathogens
- soil insects
- nematodes

### **HIGH TEMPERATURE STRESS PROTECTION#3**

#### **3. Develop Heat Hardiness**

Management to maximize the genetic heat tolerance. The result is:

- increased heat stability of photosynthesis system/heat sensitive enzymes/sensitive membranes
- higher carbohydrate (sugar) level in cells
- less succulent cells/tissues

- increased percent of “bound” water in cells
- smaller cells, thicker walls

#### **FACTORS REDUCING HEAT/DROUGHT/COLD HARDINESS**

1. **Succulence**. Poor water drainage; wet or compacted soil; excessive N; deficient K; shade; close mowing.
2. **Low Carbohydrates** (sugars). High N, close mowing; shade; prolonged high temperatures; deficient Fe, Mg, Mn, S, N; any injury.

#### **HIGH TEMPERATURE STRESS PROTECTION #4**

##### 4. **Manage for Overall Plant Health**

High temperature stress is more serious when in conjunction with other stresses:

- moisture (excessive, dry)
- light (shade)
- low soil O<sub>2</sub>
- high soil salinity
- wear, soil compaction
- disease

Also, a healthy grass tolerates a greater intensity and duration of high temperature stress.

#### **SUMMARY HIGH TEMPERATURE STRESS PROTECTION**

##### 1. **Genetic Based Tolerance**

- tolerance mechanisms for direct and indirect high temperature stresses

##### 2. **Management Influences**

- cutting height (TNC stress)
- succulence (high N, water)
- other

***Heat Tolerant Grass + Poor Management = High Job Loss***